Report on the Proposed development of Broadcasting Stations in India

By

H. L. KIRKE, A.M.I.E.E., M.I.R.E.

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REPORT ON THE PROPOSED DEVELOPMENT OF BROADCASTING STATIONS IN INDIA.

1. **Comparison of proposed expenditure in India with that in Europe.**—The Government of India has now set aside a sum of Rs. 40 *lakhs* for the development of Broadcasting in India. Whilst this is a considerable sum of money it must be emphasised that it is negligible compared to the amounts spent on broadcasting in Europe. In England, for example, there are at present nine 50 kilowatt transmitters, one 100 kilowatt and four stations of 1 kilowatt and less, whilst one of 50 kilowatts and one of 100 kilowatts are in course of erection and several more small stations are projected. This involves an expenditure of well over 100 *lakhs* for transmitting stations alone, excluding the cost of the elaborate studios which exist in all main centres—about 13 in all. On the continent of Europe similar conditions obtain. In Europe, which may be compared with India from the point of view of size and coverage, there are over 100 high and medium power stations, representing a total cost of the order of 10 crores of rupees.

The area of the British Isles is about ~~60,000~~ 89,000 square miles, while that of India is nearly two million square miles. The population of the British Isles is roughly 46,000,000 while that of India is more than 350,000,000. From this it is clear that the service which can be given to India for a sum of 40 *lakhs* will be very poor compared with that given in England.

2. **Problems in India.**—The problems of developing broadcasting in India are chiefly those of language, distance, atmospherics and poverty. There are in India vast tracts of country inhabited by a rural population living in scattered villages. Some 90 per cent. of the total population of India is found in rural districts, and it is clear that one of the main objectives of broadcasting must be to reach the village. Since, however, the average income of the Indian villager is abnormally low, and the cost of receiving sets in India at present relatively high, it is difficult to visualize any system by which village broadcasting could be made even self-supporting. And in view of the great distances to be covered, the ratio of cost to number of listeners served is likely to be extremely high.

The average size of cities and towns in India is small compared with those of Europe and the cities and towns are much further apart, with the result that whereas in Europe one station can serve a considerable number of towns, in India this will rarely be the case. Further, except for the Ganges Valley and Bengal, most of the population is in coastal areas which increases the difficulty of providing an efficient service with a comparatively small number of transmitters.

Atmospherics—that is, the disturbances caused by electrical discharges—are, no doubt, particularly heavy in India, and for that reason strong signals are more essential here than elsewhere. At the same time, I am inclined to believe that the reports of atmospheric interference in India are exaggerated (except in the case of very severe storms), and arise chiefly from the fact that, owing to weak stations and great distances, listeners in India habitually receive very weak signals.*

**Note.*—It may usefully be noted here that "man-made static"—that is, interferences caused by electrical devices such as fans, refrigerators, neon signs, etc.,—is likely to prove a source of considerable interference in India. The best way of dealing with this problem is by publicity and by bringing pressure of public opinion to bear on offenders. As in many cases the suppliers of electric devices are also the suppliers of radio receivers, the difficulty may tend to decrease as broadcasting develops.

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In all forms of interference it is not the absolute value of the interference which is important but its relation to the received signal. So long as the received signal does not fall below about 10 millivolt/metre, the listener will not be greatly troubled by atmospherics. Nevertheless the problem of atmospherics in India must be regarded as a serious one, in view of the fact that, in whatever way the sum of 40 *lakhs* may be spent, many listeners will still be receiving weak signals.

There is, unfortunately, very little data available regarding transmission and reception conditions in India, and no accurate forecast of the range of proposed stations can be made without a modicum of data on field strength and attenuation. The only data regarding the attenuation of wireless waves are those obtained by Rakshit working under Professor Mitra at Calcutta and by Bulow in Madras. These data are very incomplete. Since I have been in India some further work on these lines has been carried out, at my suggestion, at Delhi and Calcutta. The results of this work have been encouraging and seem to show that attenuation conditions in India are not very different from those in England.

3. **General discussion of the problems of wave propagation and the effect of different wavelengths.**—In general, broadcasting over distances of 100 miles or so makes use of wavelengths between 200 and 2,000 metres. This band of wavelengths is divided into two bands usually called 'medium' and 'long' waves.

Medium and long waves.

The medium wave band extends from 200 to 550 metres and the long wave band from 1,000 to 2,000 metres. The strength of signal received is dependent to a large extent upon the wave length used. At distances above 20 miles or so the signal is stronger at the longer wave lengths, but atmospherics are more pronounced.

The 'service area' of a station on medium or long waves is usually the area covered by what is known as the 'direct' or 'ground ray'. This ray becomes rapidly attenuated through loss of energy absorbed by the ground itself and by obstacles. The attenuation of the ground wave varies with wave length and with the type of ground. Flat land of good electrical conductivity has the least attenuation. Hills cause a certain amount of attenuation and local screening, but attenuation can and does become very serious on ground of low conductivity such for example as rocky ground; conductivity and therefore attenuation will even vary according to the nature of the rock and the thickness and nature of the soil covering the rock. Whatever be the absorption due to the ground, the attenuation is less for long wave lengths than for short, but atmospherics are more pronounced on the long waves than on the short. Thus we have the condition that while with the longer wave lengths the signal strength increases, the strength of atmospheric interference also increases. There will, therefore, be an optimum wavelength depending on the power of the transmitter, the type of aerial employed and the conductivity of the soil. Although, owing to the lack of data to which I have already referred, it is difficult to arrive at an accurate forecast of the range of any station, it is possible to make certain assumptions which although not strictly accurate, provide indications from which reasonable conclusions may be drawn. These assumptions

together with a general survey of the problem are dealt with in the technical appendix. From these conclusions it appears that for low power a shorter wave length in the neighbourhood of 300 metres is the best, while for high power longer wave lengths will give the best result. Whether still longer wave lengths in the neighbourhood of 1,000 to 2,000 metres would prove more satisfactory it is impossible to determine until further experimental work has been carried out in India.

Indirect Ray.

In addition to the part of the wave which travels along the ground and forms the direct ray service, a considerable part of the wave is radiated into space. This part of the wave is not attenuated by the ground. At night time there exists at a height of about sixty miles above the ground what is known as the 'Kennelly Heaviside Layer'. This is an electrified layer of the atmosphere and has the property of reflecting waves back to the ground. The amount reflected depends upon the time of day or night and upon magneto-ionic conditions which vary from day to day. The reflected wave has two effects. At distances varying from 60 to 150 miles or so, depending upon the wave length used and ground conductivity, the reflected or indirect ray interferes with the ground wave and causes fading: the degree of this fading is independent of power. This fading may be rapid and severe and may give rise to considerable distortion. At greater distances the intensity of the direct ray is so attenuated as to be negligible in comparison with the indirect ray, while the signal strength from the indirect ray increases until at a distance of the order of 400 miles or so it reaches its maximum intensity. *All* signals by the indirect ray are subject to fading, but at a distance of from 200 miles upwards the fading is in general much slower, has less distortion, and is in general less objectionable. If the signal due to this indirect ray is strong enough *in relation to atmospherics and other interferences*, it can provide a good second class service, particularly with receivers employing automatic volume control. In addition, however, to the ordinary fading, the signal is liable to vary in average strength from night to night.

Short Waves.

On the short wave lengths, below say 100 metres, the direct ray is very rapidly attenuated, so that the direct ray service of even a powerful station is only a few miles. Short waves, although they are also reflected back to the earth from the electrified atmosphere, behave differently from medium and long wave lengths, in that, in general, they are normally reflected by a different layer at a height of the order of 150 to 200 miles. Short wave transmission by the reflected ray is very much more erratic in behaviour than medium and long wave transmission and is liable to be accompanied by very rapid fading which can cause objectionable distortion. Atmospherics on the other hand are very much reduced on the shorter wave lengths and the ratio between signal and atmospherics is, in general, much greater at distances of over 100 miles on certain wave lengths in the short wave band than on the medium and long wave lengths. A number of tests have been carried out in the Dutch East Indies which show that the short wave lengths are a very useful medium of transmission for *second class* broadcast service, their useful range being roughly 50 to 500 miles, but this depends upon the wavelength used, the season of the year and

time of day. Tests have been carried out in India using the Kirkee transmitter on 31 metres, the Calcutta transmitter on 49 metres and a 20 watt transmitter owned by His Highness the Maharaja of Mysore on 49 metres. Reception from Kirkee varies considerably and is often subject to rapid fading and distortion, although signal strength is usually good. Reception of the Calcutta station is usually accompanied by considerable interference from other stations and does not in general appear to be very satisfactory. But in the test carried out from the Mysore transmitter and heard at Madras—a distance of 250 miles—the reception was remarkably good during the period of the test (7 P.M. to 8 P.M.). The normal and proper use of short waves is for long distance work. Consequently although they may be used for more or less local broadcasting they are liable not only to interfere with, but to suffer interference from stations at a very considerable distance (*i.e.*, several thousand miles). The short wave bands allotted to broadcasting are at present very congested,* and until this congestion is removed by international agreement and a proper allocation of wavelengths made, the possibility of using such wavelengths must necessarily be very limited. If short wave stations are used indiscriminately for local broadcasting, chaos will result.

4. **Comparison of low power and high power.**—The decision as to what is the best wavelength and power to use depends upon circumstances. Where there are a number of large towns and a very considerable rural population which can be included in the service area of a high power transmitter it may be desirable to use high power, but in India, generally speaking the towns are situated at great distances from one another, whilst the density of the rural population varies considerably. Under such conditions, even a very high powered station will not—except in one or two districts—provide more than *one* town and its surrounding country with a reliable service. It has been mentioned above that a second class service may be obtained at night time by means of the indirect ray and further that the usefulness of such a service depends on the strength of the indirect ray. It was originally considered that the night time service by the indirect ray from a 20 K. W. station would be a reasonable one. I have, however, taken the opportunity of listening in a number of places to the Delhi Station at night time and on every occasion, whether as near as Lahore or Lucknow or as far as Madras or Peshawar, I have found that interference by atmospherics made a reasonable service impossible. In view of what I have said above on the subject of atmospheric interference I would repeat that the question is mainly one of signal strength, *i.e.*, the strength of the Delhi Station is not sufficient to provide a reasonable night time service. I may add that I am not judging the service by the standard obtainable in Europe. A number of reports have been received from distant places to the effect that the Delhi Station has been satisfactorily received. I have taken the opportunity during my tour of India to discuss the matter with many people to find out whether they considered the night time service from Delhi satisfactory. In general I found that many did so simply because it was stronger than other stations. On the other hand, people of judgment and experience considered that the service was poor. My own opinion is that a power considerably greater than 20 K.W. will be required to give a reasonable night time service, although in the winter months a 20 K.W. station would probably give a fair service at times.

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*This difficulty is referred to in the B. B. C. Annual, 1936.

These remarks regarding the service by direct or indirect ray, are of course generalizations. There will be cases where, for example, the Delhi station is well received outside its normal range, even during the daytime, and clear of atmospherics at night, but these cases are exceptions to the general rule.

Cases of very good long range reception may occur when the receiver is located on very high ground and particularly where there is a clear line to the transmitting station, such as would occur if the receiver were located on the near side of high mountains.

5. **Coverage.**—In estimating the coverage or service area of a station various factors have to be taken into account—the power, the attenuation due to the ground, the wavelength and atmospheric and other interference. A signal on a long wave length requires greater strength than on a shorter wavelength for the same signal to noise ratio. In calculating the service areas of stations I have assumed normal ground conductivity (10^{-13}) and that the strength of atmospherics is proportional to the wavelength, although in England we normally assume that the value of a signal is inversely proportional to the square root of its wavelength. The service area cannot therefore be estimated on the basis of signal strength alone. In estimating the range of stations I have taken three figures.

an 'a' service area of 10 millivolts per metre at 300 metres wavelength;

a 'b' service area of 3 millivolts per metre at 300 metres wavelength, and

a 'c' service area of 1 millivolt per metre at 300 metres wavelength.

In all cases the actual signal strength required on any wavelength is proportional to the wavelength as stated above. In some cases it is possible that attenuation may be less than normal, but it is not safe to assume that in any district this will be so until experimental data have shown it to be the case. There are also districts where the ground conductivity is low and the attenuation greater than normal. In such districts the service area predicted will not be achieved.

In the technical appendix I have calculated the signal strength for various powers and wavelengths and plotted curves. From these curves I have plotted other curves showing 'a', 'b' and 'c' service areas for various wavelengths, taking into account the efficiency of the transmitting aerial and atmospheric and other interference.

The following table gives an indication of service areas to be anticipated for various powers:—

'a' service area.

Power.	Height of transmitting aerial assumed.	Range in Miles.	Area in square miles.	Best wavelength metres.
1 K.W. . . .	100 ft.	8	200	200—300
5 K.W. . . .	200 ft.	18	1,020	300—400
20 K.W. . . .	300 ft.	30	2,825	400—500
100 K.W. . . .	700 ft.	55	9,500	500
200 K.W. . . .	700 ft.	75	17,700	500

'b' service area.

Power.	Height of transmitting aerial assumed.	Range in Miles.	Area in square miles.	Best wave length metres.
1 K. W.	100 ft.	20	1,260	300—400
5 K. W.	200 ft.	36	4,100	400
20 K. W.	300 ft.	60	11,300	400—500
100 K. W.	700 ft.	100	31,000	500
200 K. W.	700 ft.	160	80,000	500

'c' service area.

Power.	Height of transmitting aerial assumed.	Range in Miles.	Area in square miles.	Best wave length metres.
1 K. W.	100 ft.	36	4,100	400
5 K. W.	200 ft.	65	13,300	400—500
20 K. W.	300 ft.	100	31,000	500
100 K. W.	700 ft.	160	81,000	500
200 K. W.	700 ft.	190	113,000	500

The service areas must be compared with the costs of transmitters and the following table is of interest.

(The costs are approximate and have been estimated as shown later in this report).

Power.	Cost of transmitter in lakhs of rupees.	Service areas. 'a' Range in miles.	'a' Area in square miles.	'b' Range in miles.	'b' Area in square miles.	'c' Range in miles.	'c' Area in square miles.
1 K. W. . .	1·37*	8	200	20	1,260	36	4,100
5 K. W. . .	[illegible]·83	18	1,020	36	4,100	[illegible]5	13,300
20 K. W. . .	5·0	30	2,825	60	11,300	100	31,000
100 K. W. . .	13·5	55	9,600	100	31,000	160	81,000

It will be noted that five 5 K.W. stations cost approximately the same as two 20 K.W. stations and give roughly the same service areas. But in general it is thought that five 5 K.W. stations would provide a better distributed service than would be given by two 20 K.W. stations. For reasons which I have already stated five 5 K.W. stations would serve 5 main towns as well as the rural population around them, whereas two 20 K.W. stations would serve only 2 main towns and a correspondingly greater proportion of villages. Thus even if the total rural population served in each case were the same, the total urban population would be considerably greater in the case of the five 5 K.W. stations, and it is the urban population from which income by licenses is more likely to be obtained. Moreover, it is probable that a general awakening of interest in broadcasting will be better stimulated, at any rate at first, by a number of small local stations than by a few large ones.

*This cost includes a small studio which will be housed in the same building as the transmitter. For other powers the studio is separate and not included in the above costs.

A comparison of 1 K.W. and 5 K.W. stations shows that the service area is greater in proportion to the cost with 5 K.W. than with 1 K.W. The choice between these two powers must rest upon a calculation of the total areas which it is required or desirable to serve in each district. In some cases a useful area will be served by a 5 K.W. station which would be no better, if as well, served by two smaller stations. Conversely, an important town in sparsely populated country, might be adequately served by a station of 1 K.W. or even less.

Generally speaking, I would suggest that the arguments in favour of a comparatively larger number of stations of the order of 5 K.W., as against a lesser number of 20 K.W., are in India, at the present time, very strong.

The case for a very high powered station is somewhat different and depends not only upon the particular conditions in India but also upon the desirability of acquiring further data. I believe that it is desirable—and, even with the present grant, worth the cost—to establish one really high powered station in India. Such a station would provide an invaluable indication of the possibilities of a reliable night time service over the greater part of India, and of the practicability of developing broadcasting, later on, from a few high powered stations serving vast areas, a system which may be ultimately desirable both from the strategic and financial points of view. There is, moreover, in the Ganges valley in the neighbourhood of Allahabad a point at which such a station might very well be placed, since it would include four important cities and cover an area whose language is not only more or less homogeneous but more or less common to the whole of India. It may be argued that in making this proposal I am countering my own views, advocated above, on the desirability of small stations. It should, however, be pointed out that while, *under present conditions and with present funds to draw upon*, small stations appear desirable, it is reasonably certain that large stations will have to be established as the service develops. Under present conditions, however, owing chiefly to language difficulties, the Ganges valley and Bengal alone offer suitable areas for high powered stations, and the latter, from a language point of view, would not provide a suitable night time service outside its own boundaries. It must be remembered, moreover, that broadcasting will itself tend to develop in course of time a unity of language, and may thus open up areas which are at present unsuitable, from this point of view, for long range stations.

6. **Results of tour.**—Mr. Fielden, Mr. Banerji and I have made an extensive, although rapid, tour of India. During this tour we visited the following places:—

Lucknow, Allahabad, Benares, Calcutta, Nagpur, Hyderabad (Deccan), Bezwada, Ellore, Rajahmundry, Madras, Madura, Trichinopoly, Bangalore, Bombay, Baroda and Ahmedabad.

Peshawar and Lahore had been visited during a previous tour by Mr. Fielden and myself.

I found this tour of considerable value in giving me an idea of the types of country over which service is required. The type of country was studied particularly in conjunction with figures of density of population, and the opportunity was taken of discussing Broadcasting with influential and knowledgable persons in many places. I also obtained some idea of the topographical and geological nature of the country which I should have found difficult to obtain satisfactorily from maps alone.

North-West Frontier Province.—The density of population in the North-West Frontier Province is not high, being only about the same as that of the Central Provinces. The type of country from the point of view of broadcasting is varied. The Peshawar valley is more or less flat and appears to have good conductivity and extends for from 20—50 miles from Peshawar itself. The rest of the North-West Frontier Province is, however, hilly and rocky and has presumably lower conductivity.

Whilst a small station at Peshawar will and does give a service over the flat country of the Peshawar valley, a service to the whole of the North-West Frontier Province would require a high powered station which would not be justified in view of the low density of population.

A small station of 250 watts aerial power has been erected as an experiment in Peshawar and a scheme for the supply of community receivers has been commenced on an experimental basis. The experiment appears to be a success and there is certainly no lack of enthusiasm for broadcasting. I was informed that satisfactory reception is obtained all the year round up to a distance of 30 miles and up to greater distances in winter. The range is certainly greater than would be expected from a station of this power but it may be that atmospherics are not as intense as in other parts of India.

Mr. Fielden and I took the opportunity while in the North-West Frontier Province to visit several villages in order to see for ourselves the reaction to community broadcasting and we found that very considerable interest and enthusiasm was displayed.

It would be a pity to discontinue broadcasting in the North-West Frontier Province in view of the enthusiasm which exists and further a station in this district may be of strategic importance.

The Punjab.—In the Punjab the country is mainly flat and appears to be suitable in general for broadcasting. It is being developed by irrigation canals and we were given to understand that this had led and is leading to the development of rich communities in the canal zones who should be able to afford to buy receivers. It is fortunate that in this area a hydro-electric scheme is being developed. This will, in many cases, make it possible to use mains operated receivers, even in rural districts, and so reduce maintenance costs.

A small transmitter already exists in Lahore which has been built and is run by the Young Men's Christian Association. It was constructed at the minimum of cost and is not therefore to be considered as a high class transmitter of modern design. Nevertheless, this transmitter does give a useful service over a limited area and is serving at the moment a useful purpose in keeping alive an interest in broadcasting.

The total population of the Punjab according to the 1931 Census is approximately 24 million as against approximately 49 million of the United Provinces, while the total area of the Punjab is slightly less than that of the United Provinces. Lahore is not only a rapidly growing city but an important cultural centre with a University and a large number of colleges and would be likely to provide an abundance of likely programme material. I have recommended later in this report that a high power station be

erected in the United Provinces, and whilst the Punjab does undoubtedly offer opportunities for broadcasting, it is not possible in view of the greater claim of the United Provinces and the limited resources available to consider the establishment of transmitters on a large scale in the Punjab. The Delhi station does cover a portion of the Punjab, but as I have explained before the night time signal is not sufficient to provide a service to the parts of the Punjab remote from Delhi. Therefore, I consider that one station of medium power in the Punjab would be justified.

The United Provinces and Bihar and Orissa.—The density of population in the Ganges valley is of course very high. The country is flat and has probably a good conductivity and a good service should be obtained from a station or stations in this district. The main towns are Lucknow, Cawnpore, Allahabad, Benares and Patna and the languages, I understand, are practically the same throughout the whole of the United Provinces.

As I have already noted, the Ganges valley appears to offer an ideal situation for the establishment of a high power transmitter. If this is not accepted, the alternative would be to establish smaller stations at Lucknow, Benares, Patna and possibly Allahabad or Gorakhpur.

The district of Cuttack is heavily populated, and relatively wealthy, and a low power station at Cuttack might be considered as part of future development.

Bengal.—Bengal also has a high density of population. In the Calcutta area, however, the majority of the population is situated in the city of Calcutta itself and on the banks of the Hoogly to the north of it. In Eastern Bengal, Dacca and Mymensingh the population is particularly dense, there being over 600 persons to the square mile. In the opinion of officials and non-officials who met us in conference at Calcutta, it would be more desirable to serve the congested areas in Mymensingh and Dacca than the relatively sparsely populated districts in the vicinity of Calcutta itself. This could not be done effectively from Calcutta or its immediate neighbourhood except with a very high powered transmitter.

Madras.—The Madras Presidency presents considerable difficulties in that the population is spread along the coastal area, that density of population occurs chiefly in two widely separated districts—the deltas of the Cauvery and Godavari rivers, where comparative wealth is also concentrated—and that there are two clearly defined language areas with their boundary situated just to the north of Madras city. This last factor is likely to detract considerably from the value of a high powered station placed at or near Madras itself. Moreover the power of such a station would be to some extent wasted on the sea.

It is interesting to note that, after discussing the matter at some length, a representative group of officials and non-officials in Madras did not consider that it would be advantageous to serve an area greater than about 50 miles from Madras at the expense of a service to the more thickly populated districts of Rajahmundry and Trichinopoly.

Central Provinces.—The population of the Central Provinces is, of course, relatively low compared with that of the United Provinces, Bengal and Madras, and it is doubtful whether the establishment of a station could be justified with the present resources in view of the

obvious claims of other districts. The idea, so frequently canvassed, of a short-wave station or a high powered medium wave station at Nagpur serving the whole of India is not in my view a practicable one. There are, apart from dialects, at least three distinct language areas in the Central Provinces, and this factor would militate against the effective use of a high powered medium wave station which would also largely waste its energy on sparsely populated areas. The language difficulty would be still further complicated in the case of a short-wave station serving a wider area. Moreover the arrangement of suitable programmes for such stations would be likely to prove both difficult and costly. Considerable interest in broadcasting was, however, shown during our visit to Nagpur and it was clear that there were many people who would be prepared to help in its development. This is perhaps one of the cases in which a small transmitter of say, 1 kilowatt might be established to encourage an interest in broadcasting at a point far removed from other stations, and might eventually become self-supporting.

Bombay.—In the Bombay Presidency, there are problems somewhat similar to those of Madras. The population is largely concentrated in coastal areas, and the inland Marathi speaking districts are relatively sparsely populated. The concentration of wealth and population is chiefly in and around Bombay, and in Ahmedabad. Bombay, or preferably an inland point such as Poona, might ultimately become the centre of a Marathi service, and Ahmedabad the centre of a Gujerati service: but at the latter place the problem is complicated by the proximity of the various districts of Baroda, from which no license fees would presumably be obtained, and where State schemes for broadcasting are contemplated. It would seem that Ahmedabad is a better as well as a richer centre than Baroda: on the other hand we were given to understand that if a "joint" station were established in Baroda, the Government of that State would be prepared to contribute generously towards its cost.

Sind.—The Province of Sind is so sparsely populated that, in view of the resources available, it has not been thought that there was justification for the establishment of a station in it. It is understood that the municipal authorities at Karachi are contemplating a very small scheme, and if a convenient arrangement can be made, some solution of this particular problem might be reached. I would, however, refer in this connection to my notes on "Independent developments". I have further noted under "Future development" the desirability of establishing a station at Karachi when further funds become available.

7. **Conclusions as to the most effective stations.**—It was originally proposed to erect 20 K. W. stations at Delhi, Calcutta, Madras and Bombay. When this proposal was made it was intended to spend the sum of Rs. 20 *lakhs* on Broadcasting. Since then, however, a further Rs. 20 *lakhs* has been proposed making Rs. 40 *lakhs* in all. It was further proposed to equip the Bombay and Madras stations with twin transmitters to cope with the difficulty of the two languages in each case. It has also been proposed that as Nagpur was the centre of India a station placed there would give fair service more or less covering the whole of India. In addition it was proposed to equip Delhi, Calcutta, Bombay and Madras and possibly Nagpur with short-wave transmitters.

From the figures previously mentioned regarding service areas it will be seen that a 20 K.W. station in Calcutta will by no means serve the whole of Bengal, nor would it give any effective service to the Mymensingh and Dacca Districts which are heavily populated, whilst a great part of its effective service area would be wasted on sparsely populated districts.

A 20 K.W. station at Madras would not give an effective service to thickly populated districts of the Presidency, such as Rajahmundry and Trichinopoly: it would have to serve three languages (if English be included): and at least one-third of its effective service area would be wasted over the sea.

Equally the effective service area of a 20 K.W. transmitter at or near Bombay would be largely wasted on hilly and thinly populated districts, and the sea; it is doubtful whether such a station would provide an adequate service even at Poona, whilst no reliable service would be given to more thickly populated areas such as Surat and Ahmedabad.

In considering the Madras and Bombay Presidencies it must be borne in mind that development will inevitably be influenced to some extent by the broadcasting policy of the neighbouring States. The Government of His Exalted Highness the Nizam, for instance, at present contemplates the establishment of stations at Hyderabad, Aurangabad, Gulberga, and Warangal. In Mysore it is possible that stations will be established at Bangalore and Shimoga, or in their vicinity.

After careful consideration of the amount of money available, the area to be covered, and the results up to date of the Delhi station, I am very doubtful whether 20 K.W. stations are likely to give the best results, and my opinion is that a better and more distributed service could be obtained by using a larger number of lower power transmitters. Service area is by no means proportional to the power of a station and in consequence for a given total power a greater area can be covered by a number of smaller stations than by a few large stations (*i.e.*, the same approximate area will be covered by five 5 K.W. transmitters totalling 25 K.W. and two 20 K.W. transmitters totalling 40 K.W.).

A large number of small stations does however, present the difficulty that more studios will be required and that the running cost of such a scheme will be greater than that of a few high power stations. On the other hand the useful service area will be greater and a number of small power stations will be more effective in dealing with rural programmes and the language problem, as well as stimulating local interest in broadcasting over a wider field.

In the case of a number of relatively low power stations, the programmes would, unless a satisfactory system of linkage can be devised, necessarily be less elaborate than with the fewer high power stations from the considerations of cost and available programme matter. Negotiations are already in progress with a view to developing linkage by a high frequency carrier system on telephone lines, the costs of which do not appear to be unduly high. If this system can be put into effective operation, it would automatically and almost entirely solve the difficulties of providing programmes at outlying stations.

In addition to providing a greater service area, a number of relatively low power stations will serve a greater number of towns. The urban population served will thus be considerably greater than in the case of fewer higher power stations, and from the point of view of stimulating an interest in broadcasting and the collection of revenue by licenses the urban population has to be considered.

It would, however, be of considerable interest to try the effect of at least one really high powered station. I have already given it as my opinion that the night time indirect ray service from a 20 K.W. station is inadequate. I believe, however, that a reasonable service could be obtained from a transmitter having a power of not less than 100 K. W. The most suitable district for the erection of a high powered station would be in the Ganges valley. This is a very thickly populated district, and there are several large towns which could all be served by the one high power station, *viz.*, Lucknow, Cawnpore, Allahabad, Benares. The language of this district is Hindi, which is the most universally spoken language of India and is therefore the most suitable for programmes which can be heard over a very large part of the country.

My proposals therefore for the most effective distribution of stations in India are as follows:—

(*i*) *United Provinces, Bihar and Orissa.*—A station located approximately half-way between Lucknow and Benares will be about 30 miles north of Allahabad. This station should have a power of at least 100 K.W. and should employ a high efficiency aerial. It is not possible to give any accurate estimate of the range of this station, but from the data available it is estimated that the useful range of the station will be between 100 to 160 miles for the direct ray, that is, during the day: at night time the whole of Northern India, at least, should receive a reliable signal. On a wave length of 500 metres the field strength of a 100 K. W. station would be of the order of 5 to 6 millivolts per metre at 100 miles and a wavelength of not less than 500 metres should be used. Lucknow and Benares are situated at a distance of 80 miles from the proposed high power station and the signal strength in each place should be about 9 millivolts per metre; a very good signal. Cawnpore. at 95 miles, will get about 6 millivolts per metre; still a good signal. Whether or not a wavelength above 1000 metres would be even more effective it is impossible to say without more knowledge on the subject of atmospherics, and I do not consider that any stations should use longer wavelengths until the experiments which will be discussed later in this report (under the heading of Research) have been carried out. The Cuttack District would receive a night time service from the proposed 100 K. W. station near Allahabad and it is thought that this should suffice for the present, although, since the Cuttack District is thickly populated, a station of 2 or 5 K.W. in this district may be justified as part of a future scheme.

The district around Patna will receive a service of sorts from the 100 K. W. station and while this may suffice for the present it may be found desirable to supplement the service in this district by a local transmitter of 2 or 5 K.W. as part of a future scheme.

(*ii*) *Bengal.*—As a 20 K.W. station will not serve the whole of Bengal and will not give a reasonable service to the thickly populated districts of Mymensingh and Dacca, the alternatives are, either a single station of much higher power than 20 K. W. or else a number of lower powered stations. If the money is available a single very high power station 30 miles or so north-east of Calcutta would be the best proposition, particularly as there is only one language in the whole of Bengal. Sufficient funds are not, however, available, and (since a night time service from Bengal would not be particularly suitable for the rest of India) I consider that for the time being the existing Calcutta station would be sufficient for the needs of the Calcutta District itself, and that in addition a 5 K.W. station should be established near Dacca with a small studio in Dacca and that any further development be left until further data and more money are available. If it is decided to leave the present transmitter at Calcutta for the time being then this transmitter should be brought up to date. This can be done at a relatively small cost. It has been done in the case of three similar transmitters in England which are still working satisfactorily. If, however, it is thought that Calcutta should be equipped with a slightly more powerful and more up-to-date transmitter, a station of 5 K. W. power could be installed using possibly a better aerial system than is used at present.

(*iii*) *Madras Presidency.*—The district around the city of Madras and the city itself can be adequately served by a 5 K.W. transmitter on the outskirts of Madras city. A possible site north-west of the city has been examined and thought to be satisfactory.

The Rajahmundry District can also be served by a 5 K.W. transmitter near Rajahmundry. Trichinopoly, including Tanjore and the Cauvery Delta, can be served by 5 K. W. transmitter near Trichinopoly with a studio in Trichinopoly.

In this connection it may be noted that Madura would not be well served by a 5 K. W. station at Trichinopoly as the district between Trichinopoly and Madura is both hilly and rocky and the distance is just over 70 miles. Madura is an important town with a large population and is also the centre of a thickly populated area. A low power station may be placed at Madura, if resources permit, or alternatively as part of a future scheme.

(*iv*) *Bombay Presidency.*—The city of Bombay and the outlying district up to 20 or 30 miles is served by the present transmitter and it is thought that, as in the case of Calcutta, this is relatively satisfactory for the time being if the transmitter is brought up-to-date. A 20 K. W. transmitter would increase the service area up to about 80 miles, but would not include any other large town nor would it give a service to the whole of the Presidency or to the Ahmedabad or Surat Districts. A transmitter of a few kilowatts power should be established at Ahmedabad to serve that district.

(*v*) *Lahore.*—In view of my previous remarks a 5 K.W. station at Lahore appears justified.

(*vi*) *Nagpur.*—In view of the conclusions arrived at as a result of my tour of India, already discussed, it does not appear that a high power station for the Central Provinces would be justified. But a low powered

station of the order of 1 K.W. would stimulate an interest in broadcasting in the Central Provinces. In view of the enthusiasm displayed by officials and non-officials at Nagpur, such a station would not be wasted.

(*vii*) *Peshawar.*—As a small station has been erected at Peshawar and is serving a useful purpose, it is recommended that the existing transmitter be taken over as part of the present scheme.*

Short wave.—An experimental transmitter having a power of 5 kilowatts and capable of being fairly readily adjusted to different wave lengths from 20 metres up to 100 metres should be erected with the minimum of delay so that tests may be immediately carried out to determine the useful service area obtained on different wave lengths at different times of the day and night in India and whether a useful regular service can be obtained by means of short waves. The best place for this short wave experimental station is at Delhi, mainly because it is the headquarters of the Broadcasting Service and from that point of view will be the most convenient. If it is found that a useful service can be obtained on short waves then short wave stations should be erected at Calcutta, Madras, and Bombay to work on the wave lengths which as a result of the tests from the Delhi experimental station are found to be most suitable. If, as is quite possible, short waves are found to provide a useful service, there will necessarily be a delay of two to three years before a short wave plan including stations at Calcutta, Madras and Bombay can be put into operation, and it may therefore be considered a wiser plan to proceed immediately with the erection of short wave transmitters at these places. The additional sum involved will be of the order of Rs. 5 *lakhs* and it is a matter of policy to decide whether it is worth while spending Rs. 5 *lakhs* on a speculation when for the same money two or three small power medium wave stations could be erected which would provide a definite and useful service over relatively small areas. On the whole I consider that the correct procedure is to limit expenditure, in the first place, to one short wave experimental station at Delhi, particularly in view of my previous remarks to the effect that the indiscriminate use of short waves may lead to chaos.

8. **Costs of apparatus.**—I have been supplied with specifications and prices of transmitters from both the Marconi Wireless Telegraph Company and Standard Telephones and Cables Company.

The prices are as follows:—

Power.	Marconi Wireless Telegraph Co.	Standard Telephones & Cables, Co.
	Rs.	Rs.
100 K.W.	4,81,000	5,06,600
50 K.W.	3,55,000	4,12,400
20 K.W.	2,09,000	2,61,000
10 K.W.	1,51,000	1,25,500
5 K.W.	99,000	1,08,160
2 K.W.	67,400	37,900
1 K.W.	47,000	34,400

*It is of interest to note that the Afghan Government proposes to erect a 10- K.W. station at Kabul and that this station will at times be audible in Peshawar.

It will be noted that for the higher power transmitters Marconi's quotation is the cheaper, while for 10 K.W. stations Standard's quotation is the cheaper.

Marconi, again, is cheaper than Standard for 5 K.W. stations, but more expensive for 1 and 2 K.W. stations.

In estimating the overall capital costs of transmitting stations I have assumed that staff quarters will be required for 100 K.W. and 20 K.W. stations; while for 5 K.W. stations the transmitter may be placed sufficiently close to a town where living accommodation should be available.

For high power stations and for Bombay, Calcutta, and Delhi I have allowed for large studio buildings and have provisionally allotted Rs. 2,00,000 for each. For 5 K.W. stations a less elaborate studio would be required and the cost will in consequence be less. I have allowed Rs. 70,000 at each station for studios.

Smaller stations of the order of 1 K.W. can in many cases be located inside towns and in the same building as the studio. I have allowed a total of Rs. 70,000 for studio and transmitter building and site for such stations.

I estimate the total costs as follows:—

Estimated Transmitter costs.

100 kw.

	Rs.	Rs.
Transmitter, £36,250 (Marconi)	4,84,000	
Aerial and earth (special aerial)	1,07,000	
Erection, Freight, Customs, etc. at 20 per cent.	1,20,000	
Site	25,000	
Building	1,50,000	
Power Plant	1,50,000	
Staff quarters	1,00,000	
Total	11,36,000	11,36,000

50 kw.

Transmitter, £26,100 (Marconi)	3,48,000	
Aerial and earth as above	1,07,000	
Erection, etc.	91,000	
Site	25,000	
Building	1,00,000	
Power plant	1,10,000	
Staff quarters	1,00,000	
Total	8,81,000	8,81,000

		Rs.	Rs.
20 kw.			
	Transmitter £15,650 (Marconi)	2,08,500	
	Aerial, etc. as for Delhi	30,700	
	Erection, etc.	48,000	
	Site	30,600	
	Building	68,000	
	Quarters	1,00,000	
	Power plant, extra for mains supply	8,700	
	Total	4,94,500	4,94,500
5 kw.			
	Transmitter £7,410 (Marconi)	1,00,000	
	Aerial, etc.	12,000	
	Erection, etc.	22,000	
	Site	9,000	
	Buildings	40,000	
	(Power from mains; no quarters)—		
	Total	1,83,000	1,83,000
1 kw.			
	Transmitter £2,479 (S. T. & C.)	33,100	
	Aerial, etc.	8,000	
	Erection, etc.	7,600	
	Site, buildings, etc. to include studio also	80,000	
	Furniture, musical instruments, etc.	8,000	
	Total	1,36,700	1,36,700

Note 1.—For 2 kw. S. T. & C. transmitters the cost is only slightly greater (Rs. 1,300) and from the point of view of estimating approximate costs it is immaterial whether a 1 kw. or a 2 kw. station is considered.

Note 2.—Nothing has been allowed in the above estimates for cost of line between studio and transmitter, but in most cases the line will be charged on a rental basis and will therefore come under the heading of recurrent expenditure.

Note on power costs.—For high power transmitters the power costs will naturally be a considerable item of the running costs; and it is necessary to consider this point in connection with the type of transmitter employed as the power consumption is different for different types. For a transmitter of normal design the ratio of total power to aerial power is of the order 5 :1. The Marconi Company advocate a "floating carrier" system by means of which the power is considerably reduced when there is no modulation and is appreciably reduced during normal modulation.

The Standard Telephones and Cables Company advocate a class "B" high power modulation system in which the power consumption is of the same order as that in the "floating carrier" system.

In a "floating carrier" transmitter difficulties are experienced when reception is carried out at considerable distances at night time and in the case of the Beromunster transmitter, which employs this system, it is understood the "floating carrier" is only used during the day time. The class "B" modulation system does not suffer from this difficulty.

Details of proposed scheme and costs.

			Rs.
Allahabad	M. W.	100 K. W.	11,56,000
Do.	Studios	..	2,00,000
*Delhi	M. W.	20 K. W.	3,75,000
Do.	S. W.	5 K. W.	1,50,000
Do.	Studios	..	2,00,000
*Bombay (modifications to present gear)	..	..	10,000
Do.	Studios	..	2,00,000
*Calcutta (Modifications to present gear)	..	..	10,000
Do.	Studios	..	2,00,000
**Madras	M. W.	5 K. W.	1,83,000
Trichinopoly	M. W.	5 K. W.	1,83,000
Do.	Studios	..	70,000
Rajahmundry	M. W.	5 K. W.	1,83,000
Do.	Studios	..	70,000
Lahore	M. W.	5 K. W.	1,83,000
Do.	Studios	..	70,000
Ahmedabad	M. W.	2 K. W.	1,36,700 (i.s.)
Dacca	M. W.	5 K. W.	1,83,000
Do.	Studios	..	70,000
Nagpur	M. W.	2 K. W.	1,36,700 (i.s.)
Peshawar	M. W.	0.25 K. W.	50,000
			40,19,400
Short wave relaying receiver for Delhi. (Approximate price only).	..		50,000
		Total	40,69,400

Possible additions to this scheme are stations of 1 or 2 K.W. power at Cuttack and Madura, but the erection of stations at these places may be left for the present and may form part of a later scheme. The estimated costs are Rs. 1,55,000 in each case

Note.—i.s. = including studio.

10. **Note on aerials.**—In the case of 20 K.W. station and less I have not provided for high efficiency aerials, but for 300 ft. ordinary masts in the case of 20 K.W., 200 ft. in the case of 5 K.W. and 100 ft. in the case of 1 K.W. or 2 K.W.

High efficiency aerials.—The use of high efficiency aerials is becoming increasingly popular and it is being generally realized that the theoretical high efficiency of such structures is in practice well worth while. Whether such devices are economical or not depends upon whether the increase of radiation efficiency is of greater value than the increase of cost. For high power stations there is no doubt that a high efficiency

*These stations already exist.

**In the case of Madras no provision has been made for studios as it is understood that the Madras Government is prepared to bear the cost of studios.

aerial is worth while. The results obtained from the new Lisburn station in Northern Ireland are very encouraging, and, partly as a result, the aerial system at North Scotland stations is being converted.

Prices of high efficiency radiators are much lower than they were, in fact they are comparable with the prices of aerial systems in which two masts are employed and it would be interesting to obtain quotations and to compare power gained from efficiency figures which I can supply from England. I understand that the Standard Telephones and Cables Company are prepared to quote reasonable prices for such radiators. The names of other firms can be supplied by the British Broadcasting Corporation. It is my opinion that the mast radiator type of aerial will be found suitably economic for all powers.

11. **Population served.**—The following table shows the total population served by the various stations already existing and in the proposed scheme. As far as the rural population is concerned I have obtained the figures from a map showing the density of population in various areas, while the figures for urban population have been obtained from the latest Census. The figures for rural population should be considered as approximate:—

District or Province.	Rural population served by			Main Town or Towns.	Urban Population served.
	'a' Service area.	'b' Service area.	'c' Service area.		
Punjab . .	300,000	1,230,000	4,000,000	Lahore . .	560,000
United Provinces	4,300,000	11,000,000	36,500,000	Lucknow. .	300,000
				Cawnpore .	292,000
				Benares . .	213,000
				Allahabad .	214,000
Calcutta . .	150,000	910,000	3,500,000	Calcutta . .	1,260,000
Dacca . .	715,000	2,000,000	9,300,000	Dacca . .	310,000
Central Provinces	60,000	300,000	900,000	Nagpur . .	323,000
Rajahmundry .	410,000	1,600,000	5,000,000	Rajahmundry .	170,000
Madras . .	300,000	1,200,000	4,000,000	Madras . .	647,000
Trichinopoly .	400,000	1,600,000	5,000,000	Trichinopoly .	270,000
Bombay . .	60,000	370,000	1,000,000	Bombay . .	1,271,000
Ahmedabad .	120,000	600,000	1,800,000	Ahmedabad .	399,000
Delhi . .	1,360,000	5,000,000	14,000,000	Delhi . .	447,000
Totals .	8,175,000	29,700,000	72,400,000		6,070,000

12. **Rural Broadcasting.**—About 90 per cent. of the people of India live in villages. These people are in the main very poor and unable to purchase wireless receiving apparatus. The village is an important factor in the life of the community and broadcasting is one of the best means of providing the rural population with entertainment, education and uplift programmes. Schemes for supplying villages with receivers for communal listening have been started by some provincial Governments. The scheme at Peshawar has been working for some time and is working satisfactorily. A scheme for the Punjab is just being started and other schemes are being considered. The problem of rural broadcasting is largely one of economics, but at the present time the receivers supplied to villages are expensive

and the maintenance cost is high. Such high costs will limit the development of rural broadcasting on an extensive scale and it is therefore highly desirable that work should be commenced immediately on the development of suitable receivers and maintenance facilities at low cost. Many people are interesting themselves in this matter and are carrying out or have carried out some experiments. Among these are the Agricultural Institute at Allahabad and Physics Department of St. John's College, Agra. The development of cheap receivers for rural broadcasting and maintenance facilities should be carried out by the Research and Development section and this work should be one of its most important functions. It should carry out this work in conjunction with manufacturers and further it should co-ordinate the work of other institutions. It is desirable that provincial Governments should not act separately and independently in the development and purchase of apparatus, as this would militate against the mass production of apparatus and it is by this means that receivers can best be cheapened.

In some districts the supply of electricity from hydro-electric schemes is being developed. This will simplify the problem of power supply for receivers very considerably and the maintenance cost will be greatly reduced thereby. Schemes for the supply of community receivers should, therefore, be particularly considered where electric supply is available or is being developed.

The possibility of supplying rural programmes to villages by means of lines in conjunction with central amplifiers and receivers has been proposed. I have not been able to go into this question in detail as far as costs are concerned, but I think that it should be investigated and possibly tried out.

The scheme briefly is that for a group of villages there will be one central amplifier of suitable power, the power being supplied by electric mains and the programme derived from a receiver, or where convenient and economic, by a line to the nearest studio centre. The central amplifier will connect by means of lines to each of the villages and one line may supply a number of villages. Each village will have one or more loudspeakers connected to the line and no local amplifier. The scheme is undoubtedly an attractive one from many points of view, particularly that of control. It avoids the necessity of having electrical apparatus other than the loudspeaker in the village itself and the difficulty of the villagers over discharging batteries by leaving the receiver switched on after the rural programme is finished. It is possible that with such a scheme the initial cost may be no more than that of other schemes and the maintenance cost may be less. This method of distributing broadcast programmes is in use in England and on the continent of Europe and if properly run can be very satisfactory. I have had a letter from Mr. B. H. Lyon, Managing Director of Broadcast Relay Services, Bush House, London, suggesting that such a scheme would be of considerable use in India and suggesting further that the extensive experience of the Broadcast Relay Services Company in England may be of use to the Government of India in the event of such a scheme being considered. I mention this because I know that this Company has been successful in its relay broadcasts system in England and that it works on a sound technical basis. It may be mentioned that this company has recently installed a wireless relay service in Malta which is said to be satisfactory. A mention of this method of distribution is made in B B C Annual 1936, page 134.

13. **Short wave reception of Empire programmes for rebroadcast purposes.**—Up to the present short wave reception for rebroadcasting has been done at the studio premises at 18, Alipore Road, Delhi, with a receiver on loan for test from the Marconi Company.

The receiver is not entirely satisfactory and it is necessary for efficient reception to use a site remote from sources of electrical interference and with sufficient land to instal at least two special aerials for diversity reception which reduces fading. The special aerials recommended are of the horizontal diamond type which have the effect of reducing the background noise fading very considerably; the short wave receiving station at Tatsfield in England employs such a system and the results since it has been introduced have been very encouraging.

A diversity receiving system requires a considerable area of land (about 20 acres) and special receivers. It is proposed that a suitable plot of land should be acquired immediately and a system utilizing domestic broadcast receivers of reliable make bought and put in operation for the time being. While such receivers will not give such satisfactory results as a first class relaying receiver, they will in conjunction with the special aerial system give considerably better results than the present arrangement. It is proposed that eventually a first class relaying receiver should be purchased unless it is found that the scheme employing domestic broadcast receivers is entirely satisfactory from the point of view of noise level, selectivity and stability. It has been found in England that whilst domestic broadcast receivers do give fairly good results it is necessary for the best results to use the best possible and most efficient apparatus throughout. Each part contributes its share to the overall efficiency and whilst a reduction of efficiency in any one part may not be very noticeable the combination of losses of efficiency in a number of parts may seriously affect reception.

Mr. Gopalan who is joining the Indian State Broadcasting Service as Research Engineer is familiar with these problems and the matter can safely be left in his hands.

I have allowed in the estimate a provisional sum of Rs. 50,000 for a new short wave receiving equipment and whilst this would be ample for equipment on B. B. C. lines it may be insufficient for a receiving equipment bought from a commercial company.

14. **Organization.**—I understand that it has already been decided in principle that the policy originally followed of controlling the technical staff of the Indian State Broadcasting Service from the Posts and Telegraphs Department is to be discontinued, and a separate technical organization established within the Indian State Broadcasting Service. I am in entire agreement with this decision. A divided control in broadcasting is bound to lead to difficulties and is likely to impair efficiency. It is however essential that a Chief Engineer be appointed without delay to supervise the technical and research departments of Broadcasting and to build up a satisfactory organization, especially in view of the developments which are now contemplated.

It has been proposed that an engineer from the Posts and Telegraphs Department should be seconded for duty as Chief Engineer to Broadcasting. In support of this suggestion it has been adduced that he could be replaced if necessary in case of absence or illness by other engineers of

the Department. It seems to me that this proposal carries the dangerous implication that such a man might also, and indeed probably would, be replaced as and when his own promotion or the convenience of the Posts and Telegraphs Department required it. The post of Chief Engineer to a broadcasting organization is a responsible and difficult one, and the man who fills it must be a specialist. Moreover he will have all he can do to keep abreast of developments in broadcasting and the post could not be satisfactorily filled by a series of men seconded from other branches of engineering.

I have not yet found in India any man, European or Indian, who seems to me to possess the necessary qualifications and experience for this appointment. I agree that if a suitable man could be found in the Posts and Telegraphs Department and that Department would agree to transfer him permanently to the Indian State Broadcasting Service as Chief Engineer, it would be a satisfactory solution to the difficulty. But if, as I am inclined to think, no such man is available—since on the one hand a man of long experience in the Posts and Telegraphs Department is not likely to be a specialist in broadcasting, and, on the other, that Department are not likely to wish, in any case, to part with their best men—then it seems to me essential to bring out a fully qualified man from England.

Government has already approved provisionally the appointment of a Chief Engineer from England at a salary of Rs. 1,600 per mensem on contract and although the view has been expressed that it would not be possible to tempt a man from England on such a salary for a short term contract, I do not think it would be impossible. I have already had an application for the post from one of my own staff whom I consider would do the job very satisfactorily and would come for the proposed salary, but whether or not the British Broadcasting Corporation would allow this is quite another matter, in view of the difficulty of getting suitable men for their own staff in England.

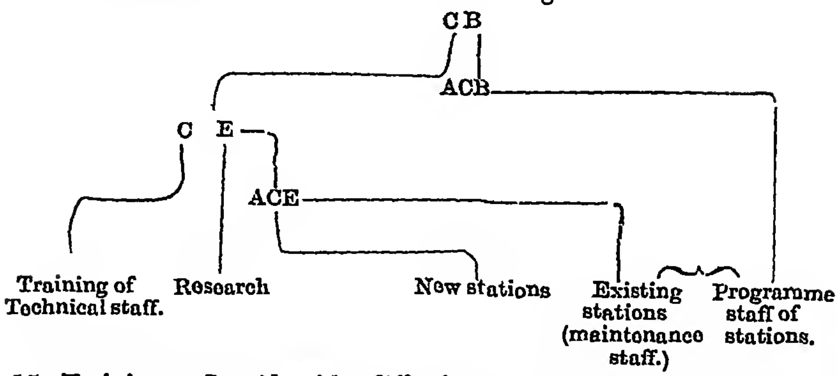
The qualities required in a Chief Engineer are technical knowledge and experience of electrical engineering, Radio engineering and Broadcast engineering, in particular the latter; in addition, for the particular circumstances of India, he clearly needs enthusiasm, initiative and energy, and ability to take responsibility.

The Chief Engineer should be directly responsible to the Controller of Broadcasting, but he should be entirely responsible for the technical side of broadcasting and the organization of the technical staff. He will direct the activities of the research department and ensure its close co-operation with the maintenance of existing stations and the erection, testing and development of new stations. He will be required to advise the Controller of Broadcasting on all technical matters and be in close touch with him in the development of new stations and new schemes.

An Assistant Chief Engineer will be required eventually and his duties should be mainly those of supervising existing stations and inspection of plant at all stations.

The engineers in charge of stations should be directly responsible to the Chief Engineer, through the Assistant Chief Engineer, in all technical matters and for the running of the stations. For day-to-day administrative purposes and for liaison in regard to the technical side of programmes they must also, of course, be responsible to their respective Station Directors.

The organization is shown in the following chart:—



15. **Training.**—Considerable difficulty has been experienced in obtaining satisfactory technical staff. For the successful working of the stations proposed in this report an efficient technical staff is required. As it is not *possible to recruit staff with sufficient* experience in India and as there is no means outside the Broadcasting Service by which such experience can be obtained, it is necessary to provide facilities for training within the Broadcasting Service. For such training an instructor will be necessary and he will require accommodation and some apparatus for the purpose.

It is desirable that candidates for such training shall have theoretical knowledge and preferably a university degree, although this in itself does not necessarily imply that the candidate is suitable. The training should be mainly of a practical nature with a sufficiency of lectures on theory to make clear the practical part of the training and some of the training should be at stations where students should understudy engineers in their everyday work of running the stations.

The choice of an instructor is not an easy matter, as the instructor must have not only a thorough knowledge of the theory and practice of radio but should have experience of broadcasting in order that he may be able to instruct students in broadcasting and be able to answer all questions put to him by his students.

The pay required by an instructor cannot be decided until a suitable man is found.

16. **Accommodation.**—Plans for the New Delhi studios in Queensway are being prepared. As Delhi is the headquarters of the Indian State Broadcasting Service, it is proposed to house the headquarters staff in the same building as the studios and station staff. Headquarters staff will consist of—

Controller of Broadcasting.

Assistant Controller of Broadcasting.

News Editor.

Editor, Indian Listener.

Chief Engineer.

Assistant Chief Engineer.

Research Engineer and research staff.

Training Instructor, etc.

Originally it was considered that the studios for the Delhi station would cost about Rs. 2 *lakhs*. With the inclusion of headquarters staff, however, the cost has been estimated to be more in the neighbourhood of Rs. 4 *lakhs*. It is therefore a question whether we should sacrifice one small station in order to keep the total cost of the scheme to approximately the Rs. 40 *lakhs* already set aside or ask Government to increase the grant to cover the additional cost of Delhi studios, or cheapen the studio premises considerably and house the headquarters staff in other premises.

The Chief Engineer, Assistant Chief Engineer, Research and Training Department could be housed in a rented bungalow of suitable dimension. Such an arrangement is workable, but a considerable amount of time would be lost by such methods, and it is presumed that if the Indian State Broadcasting Service is to be centrally controlled, an adequate building at the centre will ultimately in any case be necessary.

17. **Lines for the linking of Broadcast stations.**—It is highly desirable to be able to utilize telephone lines for linking up broadcast stations in order to economise in programme material.

India presents considerable problems in regard to the use of land lines for this purpose. The main problems are that the distances to be covered are very great and that practically all existing lines are overhead. In England and Europe most of the lines used for broadcasting are underground cables, specially adapted for broadcasting. Such cables have been found greatly superior to overhead lines.

The normal telephone equipment used in conjunction with long lines is not suitable for broadcasting, and while it has been used in this country on special occasions with some degree of success, the quality of reproduction and intelligibility leave much to be desired, and, in addition, there is considerable interruption by interference from telegraph and telephone circuits.

The Posts and Telegraphs Department is, however, anxious that broadcasting over telephone lines should be successful and has suggested the use of special broadcast carrier circuits working on existing circuits. The development of such a system can proceed at the same time that improvements are made to circuits for ordinary telephony and thus the cost will be less than if the special circuits were developed independently.

The Posts and Telegraphs Department have further suggested that they should instal the necessary equipment on the Bombay-Delhi line as the first part of such a scheme and have tests carried out. In view, however, of my proposal to instal a 100 kw. transmitter at or near Allahabad, it would be highly desirable to extend the scheme to Allahabad or to equip the Delhi-Allahabad line instead of Delhi-Bombay.

Costs of such a system.

I have discussed the matter at some length with the Chief Engineer of Posts and Telegraphs, and I have been informed by him that the very approximate costs to Broadcasting of such a scheme worked on a rental basis would be—

	Rs.
Delhi to Bombay	17,000 per annum.
Bombay to Madras	10,000 „
Delhi to Calcutta	20,000 „

Where extra branching circuits were required to supply a station on the main route there would be an additional cost of Rs. 2,100 per annum for each branching circuit and Rs. 4,800 per annum for each terminal equipment. In addition to these costs there would be the cost of ordinary lines for control purposes.

18. **Research.**—A certain amount of research work is desirable in any broadcast organisation and particularly in this country. and a small staff of research engineers is required for this work.

The work which this Department will deal with is as follows:—

1. Measurement of field strength of existing stations where necessary to provide data for future development.

2. Measurement of field strength of signals from a mobile transmitter for the purpose of testing sites for new stations and determining the service areas which such stations will have.

3. Carrying out and organizing tests from the proposed short wave *experimental transmitter at Delhi*.

4. Experiments to find out the relationship between atmospheric strength and wavelength to provide data for the determination of the best wavelengths to be used under various circumstances.

5. Experiments in rural broadcasting including the development and testing under service conditions of new types of receivers and methods of power supply.

6. Short wave reception of Empire programmes for relaying purposes.

7. Recording of programmes by the disc and other methods. The present apparatus is somewhat out of date although it was purchased only one year ago and experiments are necessary in an endeavour to effect improvements. If these are not successful it will be necessary to purchase new apparatus.

8. Development of radio link apparatus for use at outside broadcasts where lines are not available.

9. Supervision of tests on new microphones.

10. General advice on the purchase of new apparatus and in some cases the design and supervision of manufacture of new apparatus.

11. Liaison with the Posts and Telegraphs Department in regard to lines.

The following list shows the apparatus which will be required for research and development work in the Indian State Broadcasting Service. I have divided the apparatus into two categories—one which will be required immediately and the other which can be left for some little time and purchased as required:

It is only possible to give a very rough estimate of the price, and in some cases the actual price may be less than I have estimated.

	Rs.
1. Field strength measuring apparatus	4,000
2. Wave meter	1,300
3. Audio frequency amplifier for testing purposes	700
4. Attenuators and miscellaneous gear	1,300
5. Standard signal generator	1,300
6. Portable transmitter for use in connection with field strength measurements	13,000
7. Lorry for same	3,500
8. Generators, batteries, etc.	1,500
9. Car for field strength measurer	3,000
10. General purpose receiver	400
11. Batteries and other apparatus	500
12. A. C./D. C. test set (Avo meter)	200
	30,700

Staff.

1 Research officer at Rs. 400 p.m.	4,800
1 Assistant Engineer at Rs. 180 p.m.	2,160
1 Technical Assistant at Rs. 100 p.m.	1,200
1 Draughtsman and clerk at say Rs. 65 p.m.	780
1 Peon at Rs. 15 p.m.	180
2 Drivers and 2 labourers for field strength transmitter lorry	1,440
Travelling allowance	4,000
Contingencies	1,000
Furniture	1,000
Rent of bungalow, etc., for headquarters for research development	1,500
	18,060
	48,760

Additional apparatus will be required later as follows:—

1. Tone source	1,300
2. Amplifier detector	750
3. Harmonic analyser	1,300
4. Recorders for atmospheric measurements	1,300
5. Audio frequency bridge	750
6. Radio frequency bridge	1,300
7. Cathode ray oscillograph	250
	6,950

It is of the utmost importance that the apparatus required for research should be purchased without delay.

In addition a technical library should be started and subscriptions made to certain useful technical journals such as Wireless Engineer, Journal of the Institute of Electrical Engineers, Proceedings of the Institute of Radio Engineers, Bell System Technical Journal, Q. S. T. and possibly some others.

19. **Future development.**—It is not yet possible to give any forecast of future development as such development must depend to a large extent upon the results of the proposed scheme.

There is no doubt, however, that future development will include the establishment of a number of small stations to serve local needs, particularly those of rural broadcasting.

If, however, it is found by experience that the service given by the 100 K.W. station is satisfactory, it may be desirable to proceed with additional high or even higher powered stations. On the other hand if the experiments with the short-wave transmitter show that short-waves transmission does provide a satisfactory and reasonably reliable service (bearing in mind the question of world-wide interference on these wavelengths) then there is no doubt that this is a method of which the fullest use should be made if international agreement permits. Future development should certainly include small medium-wave stations at Karachi, Cuttack and Madura, in that order. Karachi and Hyderabad (Sind), though they have not been included in the present scheme, are very far removed from any proposed station and thus have a prior claim to attention when further funds are available. Cuttack will for the time being receive some sort of service from the Allahabad station and Madura from the proposed station at Trichinopoly.

The scheme which I have recommended for the present is one which I am sure will not only give the best possible results for the amount of money available but will, in conjunction with research, provide ample data for future schemes.

20. **Independent developments.**—As the enthusiasm for broadcasting develops in any country, there are bound to be a certain number of spasmodic attempts on the part of amateurs and local organisations to start independent broadcasting stations. Such stations owing to lack of funds and experience will generally be inefficient from the technical point of view and will be unable to afford sufficient funds and staff to ensure an effective programme. In the case of India the problem is a particularly difficult one since it is clear, on the one hand, that in view of the immense distances to be covered and the limited funds available any assistance in the development of broadcasting should be welcome; whilst on the other, the necessity for central control of an organization developing over so wide an area is paramount. It is doubtful whether any independent enterprise of this kind either by Local Governments, Municipal authorities or amateurs' associations is likely to help very much in the development of broadcasting in India and it is almost certain that such enterprises will eventually hinder it not only by providing services which will very often be inefficient but also by interfering with the rational development of the general scheme. It can also be prophesied with conviction that small schemes with insufficient backing will eventually find themselves unable to finance their own programmes and maintenance and will press for grants from the central authority.

I would, therefore, suggest that it is highly undesirable that licenses be issued for independent schemes unless the circumstances are very exceptional. It would seem that arrangements are already in force whereby Local Governments may, if they so desire, contribute to rural programmes and presumably this includes at present the erection of transmitters for such purposes. In my view, however, it is desirable that the initial cost of transmitters and their maintenance should be borne by the central authority, and that the contributions of Local Governments or authorities should be limited to programme expenditure, and the provision of receiving sets.

Development of broadcasting in Indian States.

Several Indian States are showing a considerable interest in broadcasting; some have already embarked on broadcasting schemes and others have asked for advice.

It is highly desirable that broadcasting in Indian States should fit in with the general scheme otherwise chaos will result in a few years when broadcasting has developed in India. It is, therefore, to be hoped that Indian States should accept the advice of the central authorities and that that advice should be freely given. This should be quite practicable when the central Engineering and Research Departments are established.

India as a whole has every opportunity to develop broadcasting on a sound and reliable basis and attempts to establish unauthorized stations and stations which do not fit in with a general scheme are to be strongly discouraged.

21. Technical Appendix.—(1) *Notes on the general theory of propagation.*—For the benefit of those who may carry out measurements of field strength for the determination of efficiency of radiation of existing stations and collection of data and for the testing of sites for new stations, the following notes are written. More detailed information may be obtained from papers published in technical journals, *e.g.*, T. L. Eckersley, Proc. I. R. E. October 1932, Paper on aerial by T. L. Eckersley, P. P. Eckersley and H. L. Kirke (Journal I. E. E.), "Service area of Broadcasting Stations" by P. P. Eckersley, (British Broadcasting Corporation publication,) C. C. I. R. documents Lisbon, "High efficiency transmitting aerials" by Professor P. O. Pedersen (a small but excellent book on the subject which contains very useful practical data) and several articles published mainly in Proc. I. R. E.

The field strength of a signal from a transmitter over a hypothetically flat earth of perfect conductivity is given by the formula—

$$E = \frac{377.h.I}{\lambda.d.}$$

where E=field strength in mv/m.

h=effective height in metres.

I=aerial current in amperes.

λ=wavelength in metres.

d=distance in km.

The aerial current I is measured at the point from which the effective height is measured or calculated. This is usually the base of the aerial.

Normally earth is not perfectly conducting and its conductivity varies with different types of soil and sub-soil. A wave does not penetrate at all into a perfect conductor but induces eddy currents of negligible loss in its surface whose field is equal and opposite to the field inducing the eddy currents. For imperfect conductors the wave has appreciable penetration and the losses due to currents induced in the earth become appreciable. The less the conductivity the greater the penetration and the greater the loss.

Sommerfeld has worked out a method of calculating the field strength for earth which is not perfectly conducting. This method applies to a hypothetically flat earth and may be used up to certain distances over which the earth may be considered sensibly flat; the distance over which the method applies depends also upon the conductivity and wavelength.

The Sommerfeld formula has been simplified into a practical form for use at wavelengths normally used in Broadcasting into an attenuation factor for use in conjunction with the formula $E = \frac{377.h.I.}{\lambda d.}$

This factor may be called "S" and is obtained from a curve (Figure 1) relating it to a factor called by Sommerfeld the numerical distance, d_n. This numerical distance is obtained as follows:—

$$d = \frac{\pi d}{2\sigma\lambda^2 c}$$

Where d = distance in *centimetres.*

λ = wavelength in *centimetres.*

c = velocity of light (*centimetres*) (3×10^{10})

σ = ground conductivity in *centimetres* in electromagnetic CGS units.

For values of d_n greater than 5, diffraction has to be taken into account and the Sommerfeld formula is no longer true.

T. L. Eckersley has made calculations in which he has used the Sommerfeld formula for short distances and a modification of the Watson formula for great distances and has combined the two to form a series of complete curves for all distances. This work is published in Proc. I. R. E. October 1932 and C. C. I. R. (Lisbon). In the full Sommerfeld formula the dielectric constant of the ground is taken into account but for normal ground at medium and long wavelengths its effect is negligible.

I have drawn a series of curves showing field strength for powers ranging from 1 KW to 100 KW and distance up to 150 miles and ground conductivities of 10^{-13} and $0{\cdot}5 \times 10^{-13}$. See figs. 2, 3, 4 and 5.

For aerials low compared with the wavelength the radiation resistance is given by—

$$R = 1580 \frac{h^2}{\lambda^2}$$

and the power radiated therefore by

$$W_r = 1580 \frac{h^2 I^2}{\lambda^2}$$

For a radiated power of 1 K.W. (a convenient figure) this becomes

$$1{,}000 = 1580 \frac{h^2 I^2}{\lambda^2}$$

$$\therefore \frac{h I}{\lambda} = \sqrt{\frac{1{,}000}{1580} W_r} = {\cdot}795\sqrt{W_r}$$

Combining this with the formula for field strength we get

$$E_d = 377 \frac{h I}{\lambda}$$

$$= 377 \times {\cdot}795 \sqrt{W_r \text{ (K W)}}$$

$$= 300 \sqrt{W_r \text{ (K W)}}$$

(2) *Effective height and radiation resistance.*—The field strength at a point on the ground is the sum of the field strengths given by the radiation from all the elements of radiation of the transmitting aerial in the vertical plane, *i.e.*, the vertical portion of the aerial *plus* the radiation from the image of the aerial in the earth. If we call the current in any element i and each element of length dh

$$\text{then: } E = K \int i \,.\, dh.$$

Thus the term hI can be taken to mean the actual height multiplied by the average value of current (geometric average taking into account phase.) As the current is usually measured at the base of an aerial a term "effective height" has been used which bears the same relation to the actual height as does the average current to the current at the base of the aerial.

The calculation of effective height is not difficult if the current distribution is known.

Experiments have shown that with certain reservations the current in a wire of uniform cross section is sensibly sinusoidal and given by the formula

$$I = I_0 \sin \frac{2 \pi l}{\lambda}$$

where I_0 is the current at a distance $\frac{\lambda}{4}$ from the free end of the aerial. *(In the case of an aerial whose electrical length is less than* $\frac{\lambda}{4}$ *i.e.,* $\frac{\pi}{2}$, I_0 is the current which would occur if the aerial had length $\frac{\lambda}{4}$).

The length in the formula is the electrical length of the wire which is greater than the physical length owing to end effects, an allowance of 5 per cent. to 10 per cent. being made for this effect in practice.

To obtain the effective height it is only necessary to integrate the current over the vertical portion of the radiation to find the average value and the effective height is obtained by multiplying the actual (physical) height by the ratio $\frac{\text{average current}}{\text{current at base of aerial}}$.

The solution of the integral is

$$-\frac{\cos x_2 - \cos x_1}{\sin x_2 (x_2 - x_1)}$$

where x_1 and x_2 are the limits in the integral. For a vertical aerial with no top $x_1 = o$ and we have therefore $\frac{\text{effective height}}{\text{physical height}} = \frac{1 - \cos(2\pi \ l_2/\lambda)}{\sin\left(\frac{2 \pi l_2}{\lambda}\right) 2\pi \frac{l_2}{\lambda}}$

where l_2 is the length of the aerial.

For $l = \frac{\lambda}{4}$, $\frac{h_e}{h_p}$ is therefore $\frac{2}{\pi}$

and for $l = \frac{\lambda}{2}$, $\frac{h_e}{h_p}$ is also $\frac{2}{\pi}$ if referred to the current at the potential node half way up the aerial where h_e and h_p are the effective and physical heights.

For aerials with a flat top the case is somewhat modified except that the effective height is still determined by the current distribution in the vertical portion.

Radiation can occur from the horizontal portion of the aerial, but does not affect the radiation in the vertical plane. It does, however, affect the total power radiated. The power radiated from the horizontal portion is wasted as far as radiation along the ground and at low angle is concerned.

For horizontal portions whose total length is less than $\frac{\lambda}{4}$ the radiation is negligible and it is usual in practice to make the length of the horizontal portion appreciably less than $\frac{\lambda}{4}$ (See paper by Moullin I. E. E. Journal).

To calculate the current distribution in the vertical portion of an aerial with a flat top it is necessary to determine the electrical length of the horizontal portion in terms of the characteristic impedance ($\sqrt{L/C}$) of the vertical portion.

We proceed as follows:—

The current in each half of the horizontal portion is given by

$$I = I_0 \sin \frac{2\pi l}{\lambda}$$

the voltage by

$$V = \sqrt{\frac{L}{C}} \cdot I_0 \cdot \cos \frac{2\pi l}{\lambda}$$

the reactance

$$\frac{V}{I} = \sqrt{\frac{L}{C}} \cot \frac{2\pi l}{\lambda}$$

where l is the length of each half of the horizontal portion.

The total reactance of the top will be $\frac{V}{2I}$ as the two halves are in parallel and the currents can be added. The effective length (l_2) of the top is therefore given by

$$\frac{2\pi l_2}{\lambda} = \cot^{-1} \tfrac{1}{2} \cot \frac{2\pi l}{\lambda}$$

To find the effective height of the aerial it is then necessary to integrate between the limits l_2 and l_4

where $l_4 = l_2 + l_3$

and l_3 = electrical length of vertical portion

and we have therefore

$$\frac{h_e}{h_p} = \frac{\cos \frac{2\pi l_2}{\lambda} - \cos \frac{2\pi l_4}{\lambda}}{\sin \frac{2\pi l_4}{\lambda} \cdot \frac{2\pi l_3}{\lambda}}$$

Example—

A "T" type aerial has a horizontal portion 30 metres long and a vertical portion 30 metres long. It is required to ascertain the effective height at a wavelength of 300 metres.

Each half of the horizontal portion will be 15 metres long; allowing for end effect the length can be taken as 16·5 metres.

Proceeding as above—

$$\frac{l}{\lambda} = \cdot055\,;\ \frac{2\pi l}{\lambda} = 19\cdot8^\circ$$

$$\cot 19\cdot8^\circ = 2\cdot77 \quad \text{approximately}$$

$$\tfrac{1}{2}\cot 19\cdot8^\circ = 1\cdot38 \quad \text{approximately}$$

$$\cot^{-1} 1\cdot38 = 36^\circ \text{ approximately}$$

The electrical length l_2 of the horizontal portion is therefore $0\cdot1\lambda$ or 30 metres.

The electrical length of the vertical portion is

$$l_3 = 30 \text{ metres} = 0\cdot1\,\lambda\,;\ \frac{2\pi l_3}{\lambda} = 36^\circ$$

The electrical length of the vertical is 36° and the total electrical length

$$l_4 = l_2 + l_3 = 0\cdot2\,\lambda\,;\ \frac{2\pi l_4}{\lambda} = 72^\circ$$

$$\therefore \frac{h_e}{h_p} = \frac{\cos 36^\circ - \cos 72^\circ}{\sin 72^\circ \times 2\pi \times 0\cdot1} = 0\cdot83$$

and the effective height therefore

$$= 30 \times 0\cdot83 = 25 \text{ metres approximately.}$$

Note.—The effective height may also be obtained by a graphical method.

In practice it has been found that this method of calculating the effective height is satisfactory, particularly for the determination of the power radiated from a transmitter used for site testing.

It is, however, very important that the current is measured accurately and represents the true current into the base of the aerial. It must not include current due to stray capacities of lead-in wires and insulators, nor current due to the capacity of the lower portion of the down-lead to buildings or to the van housing the transmitter.

The aerial should, therefore, be placed in a flat field clear of all obstacles, the transmitter removed 20 to 30 feet from the base of the down lead and connected to the aerial by means of a feeder which need not have matched impedance. The arrangement used successfully in England is shown diagramatically in Figure 6.

It is also important to break up and insulate the stays of the masts. Metal masts of height not more than 70 feet have been found not to have any serious effect at broadcast wavelengths.

In testing a site the power radiated is calculated from the aerial current and calculated effective height and the measured values of field strength at distances of 2-5 km. used in conjunction with the calculated value of E_d as a measure of the efficiency of the site for transmitting. It has been found in some instances that the measured value of field strength at distances up to 5 km. is considerably lower than should be the case for the calculated power radiated. Values as low as one half have been found in practice. These are rare and indicate a bad transmitting site with high local earth losses. It is of interest to note in this connection that the original Sommerfeld formula gives a rate of attenuation, it being assumed that a certain amount of energy is being radiated clear of the transmitting aerial. The method described above accounts for the power radiated from the aerial in its immediate vicinity and does not take account of the loss which may occur between the aerial and the point at which the field strength is measured.

(3) *Calculation of the field strength which will be obtained from a transmitter in practice from measured values of field strength.*—Measurements of field strength should be taken in all places which it is proposed to serve, several measurements being made in each district, inside and outside towns, and care being taken to avoid screening effects from electric light wires, buildings, etc. The power radiated is calculated as above. :

The value of E_d for the transmitter to be installed is next calculated from available data as to the height of masts, type of aerial, earth resistance, etc., and a multiplying factor deduced by which the measured values of field strength are multiplied to obtain the field strength which should be obtained from the proposed transmitter.

(4) *High Aerials.*—For aerials whose electrical height is greater than $\frac{\lambda}{4}$ the current at the base of the aerial is less than that higher up the aerial. For electrical lengths up to about $0.4\,\lambda$ the current will obey approximately the law $I = I_0 \sin \frac{2\pi l}{\lambda}$. For lengths of the order of $\frac{\lambda}{2}$ this no longer holds, since for a height of $\frac{\lambda}{2}$, $\sin \frac{2\pi l}{\lambda}$ would be zero which is absurd, as in that case no power could be supplied to the aerial. At the point where the reactance is zero the current multiplied by the driving voltage will give the total power.

The formula for radiation resistance $R_r = 1580 \frac{h^2}{\lambda^2}$ is based on the assumption that the vertical polar diagram is semi-circular and obeys a cosine law.

This postulates that the total height of the aerial and its image in the earth shall be small compared with the wavelength and is true for cases where the actual height is appreciably less than $\frac{\lambda}{4}$.

For an aerial whose height is greater than $\frac{\lambda}{4}$ and not greater than $\frac{\lambda}{2}$ the sum of all the elements of radiation from the aerial can only be considered as in phase in the horizontal plane. At angles to the horizontal the elements of radiation can be considered as arriving at the receiving point by paths of slightly different lengths and therefore the total received field will not be the arithmetic sum of all the elements, but the geometric sum taking phase into account. In some cases such for example as an aerial having an electrical length greater than $\frac{\lambda}{2}$ there may actually be zero radiation at one angle, and in all cases for aerials whose height is greater than $\frac{\lambda}{4}$ and less than $5/8\,\lambda$ the total radiation at angles other than the horizontal will be reduced. This will result in a saving of power and a reduction of radiation resistance. For a given

power therefore the radiation in the horizontal plane will be greater with a high aerial than with a low aerial quite apart from the earth losses.

For example, a quarter wave aerial has a theoretical radiation resistance of 36 ohms. and a half wave aerial 103 ohms. (measured at the potential node), the effective height of the $\frac{\lambda}{2}$ aerial will be double that of a $\frac{\lambda}{4}$ aerial. For a given power radiated and neglecting all losses we get $I = \frac{\sqrt{W_r}}{R_r}$.

$$\frac{E_1\, d_1}{E_2\, d_2} = \frac{I_1\, h_1}{I_2\, h_2} = 2\sqrt{\frac{R_2}{R_1}} = 2\sqrt{\frac{36}{103}} = 1{\cdot}18$$

That is to say for the same radiated power a half wave aerial will give 1.18 times the field strength of a quarter wave aerial. Where losses are taken into account the gain will be greater.

If a station has an efficient earth connection most of the losses are due to eddy currents induced in the earth and as these are a function of the total field the total resistance to be added to account for losses is the same for any height of aerial, but must be added to the radiation resistance at the potential node.

For aerials having an electrical length greater than $\frac{\lambda}{2}$ the current at the base of the aerial is in opposite phase from that above the current node, and whilst the radiation in the horizontal plane for a given current is less than if the current were in the same phase throughout the aerial, the upward radiation will be decreased to a still greater extent and the radiation efficiency thereby considerably increased. The optimum theoretical efficiency is obtained for an electrical length of .625 λ, but in practice the optimum is somewhat less usually of the order 0.58 to 0.6 λ.

It is not essential for the physical height to have this value so long as the electrical length is sufficient. The electrical length of an aerial may be increased by means of a capacity at top of the aerial or an inductance placed at some distance from the free end of the aerial or both. In general where high efficiency aerials are employed it is usual to use the mast itself as the radiator. This is because in case of aerials supported by two masts the masts interfere considerably with the radiation from the aerial and it is not possible to obtain the high efficiency which can be obtained from a single radiator.

In addition to the increase of radiation efficiency, the reduction in upward radiation reduces the fading at the limits of the direct service area and so extends the useful direct ray service area. It is of interest to note that the new 100 K.W. transmitter at Northern Ireland employs a high efficiency aerial having electrical length of .58 λ. Its fading —free range is considerably greater than that of other stations without this type of aerial, yet its signal strength in London at night time is the greatest of all British stations—the distance being 360 miles approximately.

The best method of increasing the electrical length of a mast radiator is by means of a capacity top composed of radial spokes supporting rings of copper tubing. These rings have been made as large as sixty feet in

diameter in some cases, *e.g.*, station W.H.I.O. Chicago which employs mast 500 feet in height of uniform cross section stayed at 2 points approximately 1/3 and 2/3 of the height. In addition this mast is broken by insulators at a distance of 80 feet from the top and inductance inserted to increase the electrical length still further and in consequence to raise the current node still further from the ground. This aerial is said to be very satisfactory and one of the most efficient in the United States of America. Further information as to the efficiencies, polar diagrams and driving point resistance of aerials of different heights and different arrangements is obtainable in the booklet on the subject by Professor P. O. Pedersen.

(5) *Estimation of service area of stations of various powers.*—In order to estimate the range of a station certain data is required such as the average conductivity of the ground over which the wave will pass, the wavelength, the power in the aerial and aerial dimensions and probable intensity of interference. In calculating the range and service area of transmitters I have assumed that for a 1 K. W. transmitter an aerial will be supported by a pair of 100 ft. masts, for a 5 K.W. transmitter by a pair of 200 ft. masts, for a 20 K.W. transmitter by a pair of 300 ft. masts and for a 100 K.W. transmitter a high efficiency mast radiator will be used. I have also assumed that the intensity of atmospheric interference will vary with the wavelength used, being greater at longer wavelengths than short and that the intensity will vary directly as the wavelength. In order, therefore, that in all cases the signal to noise ratio shall be the same, the signal strength required to produce a given signal to noise ratio will be proportional to the wavelength. I have assumed three service areas, which I have called (*a*), (*b*) and (*c*). The (*a*) service area will be that bounded by a field strength of 10 millivolts per metre at 300 metres and at other wavelengths proportional to the wavelength, the (*b*) service area bounded by 3 millivolts per metre and the (*c*) service area by 1 millivolt metre. I have assumed that the (*a*) service area will be sensibly free from atmospheric interference at all times, that the (*b*) service area will be free from atmospheric interference for most of the time and that the (*c*) service area will be subject to atmospheric interference for considerable portions of the time. On the above assumptions I have made calculations resulting in curves shown in figures 7 to 12. I have made calculations and curves for two values of the ground conductivity one for 10^{-13} and one for $0{\cdot}5 \times 10^{-13}$ C.G.S. units. The former is the average value in Europe and from measurements made in this country it seems that this figure will hold good in most cases. In certain districts, however, where the sub-soil is rocky, the conductivity and the range will be less. It is not possible without information regarding conductivity in bad districts to make any accurate forecast but the tables and graphs are given as a general indication.

Notes on studio acoustics.

It is necessary for broadcasting studios to have correct acoustics, and special acoustical treatment is essential for this purpose.

In a plain room with bare walls, the sound is reflected strongly from the walls and in a series of echoes which gradually diminish in intensity as the sound is absorbed by wall surfaces, carpets, etc., in the room. The time taken for a sound to die away to inaudibility is called the reverberation time and in the case of a room without any acoustical treatment this time may be several seconds.

There is an optimum reverberation time for every size of room depending to some extent upon the purpose for which it is to be used. If the reverberation time is too great the total sound will be too loud and the reverberant sound will interfere with the direct sound and cause muddling and lack of intelligibility. If the reverberation time is too short the room will sound too dead and while diction will be particularly clear, the sound intensity will be low and music will lose considerably in brilliance and tone.

One of the great difficulties in acoustic treatment is that most sound-absorbing materials absorb more sound at high notes than at low with the result that a studio treated acoustically with such a material will deaden all middle and high notes, and particularly overtones. Low notes on the other hand will become exaggerated in intensity and produce excessive reverberation. This has a very unpleasant effect.

Wood panelling has the property of absorbing more sound at low notes than at high and in a room with a considerable amount of wood panelling the sound will be hard and lacking in body, while speech will be rather clear but hard in tone.

Considerable experimental work has been done in England, America and the Continent of Europe, but the perfect acoustic material has yet to be found. Most of the studios in England are treated with building board which is cemented directly to the walls and although many of the studios thus treated have been reasonably satisfactory, it is not considered that this treatment should be continued as building board has the property, mentioned above, of absorbing more at high than at low notes.

A material successfully used in America is that known as rock wool. This material is made by melting rock and forcing it through very fine holes. It looks like cotton wool or glass wool, and is not affected by heat or moisture, nor is it liked by insects. A similar material is slag wool, which, as its name implies, is made from slag. It is not so satisfactory as rock wool for mechanical reasons and it is not thought that it would be suitable for use in this country. Rock wool would however be satisfactory but its cost is high.

A method of using building board which is said to be more satisfactory than that of cementing it to wall surfaces is to fasten it to 1/4" battens spaced 10" apart, so that the building board is spaced 1/4" from the wall surface. The air space behind the wall board acts as damping and prevents the drumming or diaphragm effect which is normally caused by fastening such material at edges. This treatment has been developed by the Celotex Company and appears to be a possible solution to acoustic problem in this country.

A treatment which has been used recently in England and is said to be very satisfactory is that of hanging Cabots quilt, a material made of reed grass compressed and sewn between two sheets of canvas, spaced from the walls by about a foot. This treatment, while successful, is at present in its experimental stage and has not therefore been considered in connection with a decorative scheme, and does present difficulties from this point of view.

As the science of acoustics is advancing so very rapidly at present, it would be advisable to wait until the last possible moment before deciding what treatment should be used. Experiments are at present in progress by the British Broadcasting Corporation in England which may lead to a

successful and reasonably cheap acoustical treatment and it would be unwise to specify acoustical treatment unnecessarily early when by waiting a better method may be available.

Considerable information on the subject of acoustics is contained in a paper on the "Acoustical design of studios for broadcasting" by H. L. Kirke and A. B. Howe, and published in the Journal of the Institute of Electrical Engineers. This paper gives curves showing the optimum reverberation period of studios of various sizes. In general the lower curve giving a lower reverberation time should be used.

The formula for calculating the reverberation time of a studio is—

$T = \dfrac{0\cdot 05\,V}{2\cdot 303\,[\Sigma\cdot\ S.\log_{10}(1-\alpha)]}$ where T is the time in seconds V is the volume in cubic feet α is the absorption co-efficient of each material used and S is the surface area of each particular material used.

From this formula the amount of absorbing material required to give any desired reverberation time can be calculated for any particular frequency and if this is done for various frequencies, a curve connecting reverberation time with frequency can be plotted.

Experiments have also been carried out in England to study the effect of making wall and ceiling surfaces irregular. The effect is to reduce the apparent reverberation time, and is not yet fully understood. Nevertheless, it may be said that studios with a certain amount of irregularity in the wall surfaces such as could normally occur in the architectural design will be not only satisfactory but helpful to the acoustics.

Another system of acoustic treatment used in America is that known as "live end dead end treatment". In this system the end of the studio where the music is played is made live while the end where the microphone is situated is made dead, the argument being that performers like a live effect while the microphone is more suitable in an acoustically dead environment. This system is said to produce satisfactory results, although it is understood that in many cases such a studio is crowded with performers which tend to nullify the live end dead end effect as many of the performers will be playing in the dead end of the studio.

NOTE BY THE CONTROLLER OF BROADCASTING.

The foregoing report has been prepared in close consultation with me, and I can therefore state that I am in agreement with the conclusions reached in it. It remains for me only to add a brief comment on the recurrent expenditure which is likely to be involved when the network of stations proposed in the report has been established. The figures which I shall submit in this connection can of course be regarded only as approximate, but I do not think that they need be exceeded.

2. A sum of approximately Rs. 300 a day per station is the present "programme expenditure" of the Indian State Broadcasting Service. It must be remembered that this sum has to include travelling allowances of artists and speakers, the upkeep of studios, trunk lines and many other items which cannot be classed as direct payments to artists. It is on the whole quite insufficient for a first class programme, especially at stations where talent is not easily procurable in the immediate neighbourhood. The total annual cost of programmes under this head at the Delhi, Bombay and Calcutta Stations is Rs. 3,17,800. The present total annual average cost of staff at the three stations is Rs. 1,59,108. The total annual cost of power for the three stations is Rs. 44,500. These figures, to which must be added Rs. 3,16,692 for miscellaneous items, such as technical maintenance, news services, purchase of instruments, royalties, furniture, rent of premises, radio publications, etc., bring the total budget of the Indian State Broadcasting Service (excluding Headquarters Office) to Rs. 8,38,100.

The annual income from customs duties on wireless receiving sets amounted in 1935-36 to Rs. 10,80,000.* The total income from licenses was Rs. 2,72,100. The total income derived from broadcasting was, therefore, Rs. 13,52,100 and shows every sign of increasing rapidly. It may, therefore, be said that the Indian State Broadcasting Service, with an annual expenditure of Rs. 9,40,000 (including the expenditure on Headquarters and a special grant for research) and a proposed capital expenditure of Rs. 40 lakhs, is still paying its way, and is likely to continue to do so under the present arrangements.

3. But, the addition of nine new broadcasting stations, radiating a daily programme, must of course entail a heavy increase in recurrent expenditure. It is unlikely that popular response will be quick enough to pay, at any rate for the first year or two, more than a part of this additional burden, and Government will have to be prepared to meet it, and to meet it effectively. It is clearly quite useless to embark on any scheme for the establishment of a number of stations unless the staff and resources of those stations are such as to ensure an efficient and attractive programme service, which will by degrees popularise broadcasting and thus bring in sufficient funds to permit further expansion.

A. I will take, first, the staff which will in my view be necessary for the stations which have been proposed.

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* The income from this source for the first three months of 1936 was Rs. 3,93,000.

One 100 kilowatt station.

	Pay.	Average cost per mensem.
(a) Programmes.	Rs.	Rs.
1 Station Director	750—25—900 *plus* special pay Rs. 150	993
1 Assistant Station Director . . .	300—20—600	457
1 Programme Director	200—10—300	273
8 Programme Assistants (Rs. 187 each) .	150—5—200	1,496
2 Announcers (Rs. 137 each) . .	100—5—150	274
2 Translators (Rs. 187 each) . . .	150—5—200	374
1 Sub-Editor for vernacular programme paper	150—10—300	244
		4,111
(b) Technical.		
1 Transmitter Engineer . . .	300—20—600 *plus* special pay Rs. 50	507
1 Studio Engineer	300—20—500	446
3 Assistant Engineers (Rs. 273 each) .	200—10—300	819
11 Technical Assistants (Rs. 138 each) .	100—10—150	1,518
2 Mechanics (Rs. 73 each) . . .	30—3—84—4—100	146
1 Supervisor for Power Plant . .	200—10—300	273
2 Power Plant Engineers (Rs. 138 each) .	100—10—150	276
		3,985
(c) Clerical and Inferior.		
1 Accountant	150—10—250	223
2 Grade I Clerks (Rs. 143 each) . .	100—4—120	246
2 Stenographers (Rs. 134 each) . .	50—5—150 *plus* compensatory allowance of Rs. 30 per mensem.	268
6 Grade II Clerks (Rs. 73 each) . .	45—45—3—90	438
2 Car Drivers (Rs. 45 each) . . .	30—2—50	90
2 Telephone Operators (Rs. 30 each) .	30	60
1 Duftry	18—1/2—26	23
1 Head Peon	18—1/2—26	23
9 Peons (including Chowkidars Rs. 16 each)	15—1/5—17	144
		1,515
	Total per mensem .	9,611
	Total per annum .	1,15,332

One 5 kilowatt station.

	Pay.	Average cost per mensem.
(a) Programmes.	Rs.	Rs.
1 Station Director	300—20—600 *plus* special pay Rs. 50 p. m.	507
3 Programme Assistants (Rs. 187 each) .	150—5—200	561
1 Announcer	100—5—150	137
		1,205
(b) Technical.		
1 Engineer-in-Charge	200—10—300 *plus* special pay Rs. 50 p. m.	323
1 Assistant Engineer	200—10—300	273
3 Technical Assistants (Rs. 138 each) .	100—10—150	414
2 Mechanics (Rs. 73 each) . . .	30—3—84—4—100	146
		1,156
(c) Clerical and Inferior.		
1 Accountant	100—5—150	137
2 Grade II clerks (Rs. 73 each) . .	45—45—3—90	146
1 Car Driver	40	40
5 Peons (including Chowkidars Rs. 16 each)	15—1/5—17	80
		403
	Total for one Station per mensem .	2,764
	Total for one Station per annum .	33,168
	Total for five Stations per annum .	1,65,840

One 2 kilowatt Station or less.

	Pay.	Average cost per mensem.
(a) Programmes.		
1 Station Director . . .	200—10—300 *plus* special pay Rs. 50 p. m.	323
2 Programme Assistants (Rs. 187 each) .	150—5—200	374
1 Announcer	100—5—150	137
		834
(b) Technical.		
1 Station Engineer	200—10—300	273
2 Technical Assistants (Rs. 138 each) .	100—10—150	276
1 Mechanic	30—3—84—4—100	73
		622

(c) *Clerical and Inferior.*	Pay.	Average cost per mensem.
	Rs.	Rs.
1 Accountant and Head Clerk	100—5—150	137
2 Grade II clerks (Rs. 73 each)	45—45—3—90	146
1 Car Driver	40	40
5 Peons (including Chowkidars Rs. 16 each)	15—1/2—17	80
		403
Total for one Station per mensem		1,859
Total for one Station per annum		22,308
Total for three Stations per annum		66,924

Additional Staff for the Delhi Short-wave Transmitter.

(a) *Programmes.*		
1 Programme Assistant	150—5—200	187
1 Announcer	100—5—150	137
(b) *Technical—*		
1 Assistant Engineer	200—10—300	273
1 Technical Assistant	100—10—150	138
1 Mechanic	30—3—84—4—100	73
Total cost per mensem		808
Total cost per annum		9,696

The additional staff required to work the scheme will, therefore, involve a recurrent expenditure of approximately Rs. 3,60,000.

B. I now come to the recurrent expenditure on power. Here especially the figures must be regarded as approximate as they will vary with the varying cost of power in different districts. In the case of the 100 kilowatt station it would probably be necessary to generate power. I have however, allowed a fairly wide margin in all cases.

One 100 kilowatt station. (Class B or Floating Carrier).

		Per annum. Rs.
Input of 400 kilowatts for a 12 hour programme (taking cost at 1 anna per unit) Rs. 300 per day		1,09,500
One 5 kilowatt station.		
Input of 30 kilowatts for an 8 hour programme (taking cost at 2 annas a unit) Rs. 30 per day	10,950	
Multiplied by five		54,750
One 2 kilowatt station.		
Input of 15·4 kilowatts for a 6 hour programme Rs. 12 per day	4,400	
Multiplied by three		13,200
Total cost of power		1,77,450

C. Thirdly there is the cost of programmes. Any forecast of the programme expenditure is complicated by—

(a) the fact that programmes may be made to cost anything, depending on the policy and resources of the broadcasting organization, and the varying fees of artists;

(b) the possibility that, by developing its own schools of music and drama, and by engaging artists on long term contracts, a broadcasting organization may considerably reduce the cost of programmes—but the reduction will be a gradual one;

(c) the possibility that in India during the next year or so trunk telephone communications will be so developed and improved as to allow successful simultaneous broadcasts over the whole, or part of, the network, thus immensely reducing programme costs.

Bearing these possibilities in mind, and allowing that small and outlying stations, at any rate in their initial stages, may have to be content with programmes less ambitious than higher powered stations serving a greater number of listeners, I would assess approximate Programme expenditure as follows:—

		Rs.
One 100 kilowatt station.		
Rs. 350 per day		1,27,750
One 5 kilowatt station.		
Rs. 200 per day	73,000	
Multiplied by five		3,65,000
One 2 kilowatt station (6 hours only).		
Rs. 100 per day	36,500	
Multiplied by three		1,09,500
Total programme expenditure		6,02,250

D. *Miscellaneous Expenses.*—Here again the figures must be regarded as approximate only. They are based upon the experience obtained at other stations and upon reasonable anticipations of development in such matters as trunk line facilities and news services.

	Rs.
*Equipment	1,15,000
Transport and maintenance	30,000
Repairs to Buildings	16,000
Technical maintenance	50,000
†Hire and purchase of instruments, etc.	40,000
Service postage and telegrams	10,000
Rents, rates and taxes	9,000
Telephone charges	9,000
Office expenses, etc.	9,000
News services	25,000
Radio publications	12,000
‡Linkage by Trunk lines	75,000
Total	4,00,000

* This figure is intended to cover the equipment and furnishing of eleven studio premises and maintenance.

† Including recording apparatus and the cost of transcription programmes, and the annual payment to Gramophone Companies in India.

‡See page 23 of report.

E. The expenditure contemplated must also include that of a Central Engineering Branch, to supervise the establishment of stations and their subsequent maintenance. This work has, up to the present, been left in charge of the Posts and Telegraphs Department, but with the development contemplated such an arrangement is likely to prove more costly and less efficient than a Central organization on the following lines:—

No.	Designation.	Scale of pay.	Average.
		Rs.	Rs.
1	Chief Engineer	1,500—50—1,700	1,600
1	Deputy Chief Engineer	750—25—900	843
1	Office Superintendent (for the Chief Engineer)	400—20—500	480
2	Assistants	140—10—280—10—310—15—400	506
1	Stenographer	125—5—180—10—300	213
3	Clerks and typists	60—2—80—3—125	270
2	Draftsmen	80—4—120—5—200	218
1	Duftry	15—1/2—20—1—30	23
4	Peons 1 (1st Grade)	16	16
	1 (2nd Grade)	15	15
	2 (3rd Grade)	14 each	28
		Total per mensem	4,212
	Total cost per annum=Rs. 50,544 *plus* Rs. 9,456 for contingencies		60,000

F. With the development proposed it is clearly necessary to allow for some expansion of the Headquarters Staff, which at present is a small one. Under this heading allowance must be made for All-India services such as News, Editoral staff, Research, and Training. I would assess the figures roughly as follows:—

	Rs.
Administrative staff	35,000
News Editorial staff	40,000
Research and Training	40,000
Contingencies	15,000
Total	1,30,000

The total recurring expenditure, therefore, including all new and present stations (I would point out that the new stations proposed will take some three or four years to establish, and the recurring expenditure is not

therefore likely to rise to the full figure until licenses and customs receipts have also risen) may be taken to be approximately as follows:—

			Rs.
1. Staff	Present		1,59,108
	New		3,60,000
2. Power	Present		44,500
	New		1,77,450
3. Programmes	Present		3,17,800
	New		6,02,250
4. Miscellaneous	Present		3,16,692
	New		4,00,000
5. Central Engineering Organization			60,000
6. Administrative staff	Present		61,800
	New		35,000
7. News Editorial staff			40,000
8. Research and Training			40,000
9. Contingencies			15,000
		Total recurring expenditure	26,29,600

It appears to me that, as broadcasting develops, it may reasonably be anticipated that a large part. if not the whole, of this expenditure may be met from increased receipts either in the form of license fees, customs duties, or both.

In conclusion it should be clearly stated that the report, and the proposed arrangement of stations, have been based on a compromise between providing a service to urban areas, from which license revenues may be anticipated, and providing such service to rural areas as may be offset in cost, at least to some extent, by the revenue obtained from urban areas. So long as the Indian State Broadcasting Service is regarded more or less as a commercial undertaking and not as a social service, such considerations must affect its development: but, under such conditions, rural areas of comparatively sparse population—which, it might be argued, are actually more in need of broadcasting than richer and more populous districts—are necessarily excluded from its scope. It may be thought that the idea of a self-supporting service is wrong, and that Government should devote the limited funds available to "unremunerative" stations in rural areas. There are several good reasons for holding the more mercenary view. If broadcasting is to develop as it should, the Service must have a life of its own and strength to survive budgetary fluctuations. In the early stages at least vitality can come only from the body of sophisticated listeners who are prepared to pay for their entertainment. Generalizations about the value of rural broadcasting are not necessarily correct, and in actual fact little is known at present of the rural side of broadcasting problems. It is quite arguable that if Government are prepared to devote Rs. 40 *lakhs* initial and Rs. 26 *lakhs* recurrent to Social Services in rural areas, they might find better objects of expenditure than broadcasting. But if Government allot these sums to a rationally prepared broadcasting scheme, the probability is that they will, without imposing an additional burden on the general taxpayer, provide a service *both* for the towns *and* for the villages, which has within it the seeds of development on a self-supporting basis.

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